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EVALUATION OF DIFLUBENZURON FOR CONTROL OF LEAFROLLERS (LEPIDOPTERA: TORTRICIDAE) ON APPLE

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ABSTRACT

The toxicity of diflubenzuron (Dimilin) to various stages of the obliquebanded leafroller, *Choristoneura rosaceana* (Harris), was evaluated under laboratory conditions. The compound had no ovicidal effect at concentrations up to 1000 ppm but foliage treated with 100 ppm diflubenzuron plus the surfactant, Tween 20, was toxic to 1st-instar larvae. At similar concentrations, diflubenzuron reduced the longevity of adult moths but had no effect on fecundity or egg viability.

In an orchard of mixed apple cultivars, diflubenzuron cover sprays applied at the pink bud stage significantly reduced fruit damage by leafrollers but failed to provide control comparable to that with azinphos-methyl.

INTRODUCTION

Recent field studies have suggested that the insect growth inhibitor, diflubenzuron (Dimilin), has considerable potential in pest management programs in pome fruits (Wearing and Thomas 1978; Westigard 1979). Against the codling moth, *Laspeyresia pomonella* L., the compound had excellent contact and residual activity to eggs but limited toxicity to larvae and adults (Elliott and Anderson 1982). Despite this, diflubenzuron sprays applied to coincide with peak codling moth activity provided control similar to that of azinphos-methyl in an Okanagan orchard (Anderson and Elliott 1982). In addition, diflubenzuron appeared compatible with integrated mite control in that sprays were non-toxic to predaceous mites and did not increase populations of European red mite, *Panonychus ulmi* (Koch) or rust mites (*Aculus* spp.).

Depending upon the species, leafrollers can cause early and late season injury to apples. In the northern fruit growing region of British Columbia, two univoltine species, *Archips argyrospilus* (Walker) and *Archips rosanus* (L.), predominate and cause early season damage whereas in the southern region, two bivoltine species, *Choristoneura rosaceana* Harris and *Pandemis limitata* Rob., are more frequent and cause both early and late season injury (Madsen and Madsen 1980). As the timing of diflubenzuron sprays may be critical to optimal control (cf. Westigard 1979; Elliott and Anderson 1982), preliminary laboratory tests were conducted to determine which stages of the obliquebanded leafroller, *C. rosaceana* (a representative leafroller species), were sensitive to the compound. Subsequently, we evaluated the efficacy of several diflubenzuron treatments and azinphos-methyl against leafrollers under orchard conditions.

MATERIALS AND METHODS

Egg masses of *C. rosaceana* were collected from Okanagan orchards by Dr. H. F. Madsen. A stock colony was established by rearing the leafroller larvae on broad beans (*Vicia faba* L.). The colony was maintained in a greenhouse under a 16L:8D photoperiod, variable temperatures (20-30°C) and relative humidity (70-95%). However, the unnatural rearing conditions, coupled with poor egg viability, limited the numbers of insects available for the laboratory study.

Egg masses of *C. rosaceana* were treated topically with aqueous solutions of diflubenzuron (Dimilin 25WP; 1-(4-chlorophenyl)-3-(2,6-difluorobenzoyl)urea; Thompson-Hayward Chem. Co.). Five egg masses consisting of about 440 eggs/mass were treated at each concentration. The effect on % egg hatch was recorded when larval eclosion was complete. In some egg masses, including those in the check treatment, none of the eggs hatched. Because these egg masses had likely not been fertilized, they were excluded from the analysis.

Larvicidal activity was assessed by placing 1st-instar larvae on pear foliage which had been dipped in solutions of diflubenzuron, with or without the surfactant, Tween 20. There were three larvae/leaf and three leaves/treatment. The effect on larval survival was determined after 14 days.

Adult moths were dipped in solutions containing diflubenzuron plus Tween 20 and the effects on longevity, fecundity and egg viability determined. Each treatment was replicated four times with each replicate consisting of four moths of each sex.

During 1980, field tests were conducted in an orchard of mixed apple cultivars at the Agriculture Canada Research Station, Summerland. Five treatments were arranged in a randomized block design with five blocks and five replicates/treatment. Each replicate consisted of three adjacent trees separated from the other replicates by at least one buffer tree. During the pink bud stage of McIntosh cultivar, 500 leaf clusters were collected randomly from throughout the orchard. These samples indicated that the leafrollers were predominantly 1st-or 2nd-instar larvae/100 leaf clusters. On April 26, sprays were applied to run-off with a conventional handgun sprayer at a pressure of 21 kg/cm^2. Using the trapping lethods described by Madsen and Madsen (1980), the numbers of tortricid moths were monitored until mid-August. Because the traps could not be inspected at regular weekly intervals, moth captures were expressed as numbers of moths/trap/day. At harvest, the efficacy of the treatments against leafrollers was assessed on the basis of % damaged fruit.

RESULTS AND DISCUSSION

Table I shows the % hatch of egg masses treated topically with varying concentrations of diflubenzuron. Although egg hatch was low in the check treatment, it was apparent from the % hatch values that egg masses of *C. rosaceana* were insensitive even to 1000 ppm diflubenzuron. Despite a conspicuous diflubenzuron deposit on the egg masses in the 1000 ppm treatment, the emergent larvae appeared normal and showed no ill effects later. The inactivity of diflubenzuron against leafroller eggs was unexpected because the compound has a pronounced ovicidal effect on other related species (Ascher *et al.* 1980; Elliott and Anderson 1982). However, the egg masses of *C. rosaceana* are covered with a cement-like gelatinous secretion

TABLE I. Percent hatch of egg masses of **C. rosaceana** topically treated with varying concentrations of diflubenzuron.

Diflubenzuron concentration (ppm)	% hatch (mean ± S.E.)
0	57.2 ± 1.0
1	63.1 ± 15.0
10	42.4 ± 18.3
100	77.6 ± 3.8
1,000	60.0 ± 7.1

TABLE II. Percent survival of first-instar larvae of **C. rosaceana** feeding on pear foliage which had been dipped in diflubenzuron/Tween 20 solutions. In this and remaining tables, " + " denotes presence and " – " absence of Tween 20.

Diflubenzuron concentration (ppm)	500 ppm Tween 20	% survival (mean ± S.E.)
0	-	44.5 ± 11.1
0	+	88.9 ± 10.7
10	-	66.7 ± 19.4
10	+	55.5 ± 11.7
100	-	55.5 ± 11.7
100	+	11.1 ± 11.0

Factorial ANONA:diflubenzuron-Tween 20 interaction was significant (P = 0.05)

from the accessory glands which could prevent the entry of diflubenzuron into the eggs.

Compared with the other treatments, foliage treated with 100 ppm diflubenzuron plus Tween 20 was very toxic to 1st-instar leafroller larvae (Table II). Factorial analysis of variance indicated that Tween 20 significantly enhanced the toxicity of diflubenzuron to the larvae.

Compared with the check treatment, 100 ppm diflubenzuron significantly reduced the longevity of adult moths but had no effect on fecundity or egg viability (Table III).

Collectively, the laboratory tests indicated that the efficacy of diflubenzuron against leafrollers would depend primarily upon its larvicidal activity. Since numbers of 1st- and 2nd-instar larvae in the test orchard exceeded the economic threshold of 10 larvae/100 leaf clusters (Madsen and Carty 1977), diflubenzuron and azinphos-methyl cover sprays were applied during the pink bud stage. The trap

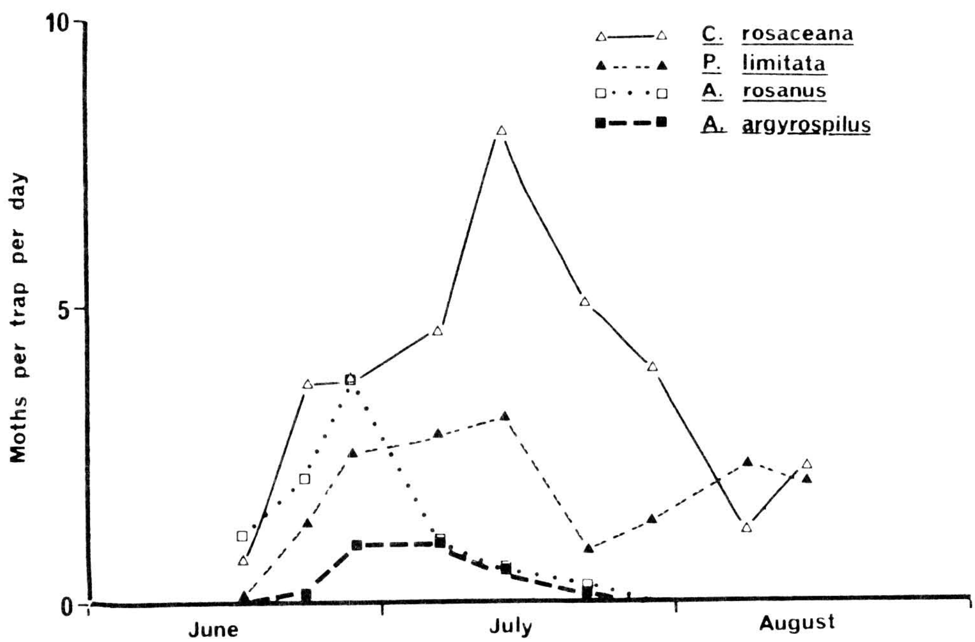

Figure 1. Numbers of male moths of four leafroller species captured daily in pheromone traps in test orchard.

TABLE III. Longevity, fecundity and egg viability of **C. rosaceana** moths dipped in solutions of diflubenzuron and Tween 20.[1]

100 ppm diflubenzuron	500 ppm Tween 20	Male longevity* (days)	Female longevity* (days)	Fecundity (eggs/female/day)	% hatch
-	+	5.8 ± 0.6[a]	6.2 ± 0.7[a]	42.5 ± 4.7[a]	49.6 ± 3.5[a]
+	+	4.3 ± 0.6[b]	5.2 ± 0.6[b]	42.1 ± 6.9[a]	52.1 ± 6.4[a]

[1]Means in the same column followed by the same letter are not significantly different at P = 0.05

TABLE IV. Percent of harvested apples from the orchard showing damage from four leafrollers species.

Treatment	94 ppm diflubenzuron	375 ppm diflubenzuron	375 ppm azinphos-methyl	500 ppm Tween 20	% damage (mean ± S.E.)
A	-	-	-	-	15.8 ± 1.4
B	+	-	-	-	12.1 ± 0.9
C	+	-	-	+	10.2 ± 0.8
D	-	+	-	-	7.9 ± 0.9
E	-	-	+	-	1.9 ± 0.3

Contrasts:
(A) vs. (B+C+D+E) - highly significant P = 0.01
(B) vs. (C) - not significant.
(B) vs. (D) - significant.
(D) vs. (E) - significant.

captures indicated that two-generation leafrollers were the most abundant species in the test orchard (Fig. 1). The catch probably represented moths from the first generation (cf. Madsen and Madsen 1980).

Table IV shows the % harvested apples with leafroller damage. In the check treatment, fruit damage was very high, exceeding 15%. At the lower application rate (94 ppm), diflubenzuron provided poor control even when Tween 20 was added. At the higher rate (375 ppm), diflubenzuron provided significantly better control than in the previous treatments and reduced fruit damage to 7.9%. However, at a comparable application rate, azinphos-methyl provided roughly four-fold better control than 375 ppm diflubenzuron. Although these findings indicate that diflubenzuron is not an effective control agent for leafrollers, improved liquid formulations (cf. Ascher *et al.* 1980), more active analogues (Retnakaran 1979) or integration with *Bacillus thuringiensis* (Wearing and Thomas 1978) may overcome this limitation.

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